NOTES ON THE INSECT PARASITES OF THE SPRUCE BUDWORM[1] *CHORISTONEURA FUMIFERANA* (CLEM.) IN BRITISH COLUMBIA.

by
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Running title — Wilkes, Coppel, Mathers — Parasites of Spruce Budworm.

INTRODUCTION

The spruce budworm, *Choristoneura* (*Archips*) *fumiferana* (Clem.) (Tortricidae) has long been considered one of the most injurious forest insect pests in Canada. A general account of past outbreaks and an outline of its biology and habits are given by Swaine and Craighead (1924). At the time these studies were made investigations were also undertaken by J. D. Tothill and A. B. Baird on the parasites and other natural control factors of the spruce budworm, but although a good deal of work was done, brief reference to which is made by Hewitt (1911, 1912, 1913), very little has been published.

During the present outbreak, interest in this work has been revived and as part of the general control programme of studies an attempt has been made by the Dominion Parasite Laboratory, in co-operation with the Forest Insects Unit, to establish in Eastern Canada parasites found by Tothill (1923) and Baird to be present only in certain areas of British Columbia. During the course of this work large collections of budworm have been made and reared for the recovery of parasites. A report on the progress of the work and the number of parasites released in Eastern Canada to 1946 has been given by Wilkes (1946). In addition to the parasite species selected for liberation many others were reared from the collections. Over 45 species have been reared, many of which have not previously been recorded as parasites of this host.

Since the inception of the present study a great deal of data has accumulated on the general parasite complex of *C. fumiferana* and although the work is being continued, it is considered advisable to put on record some of the findings made to date. This paper is, therefore, a summary of the preliminary aspects of the work and is presented largely with a view to bringing together all previously published records of insect parasites attacking this species in North America and to add records of other parasites reared from collections made during the present investigation. Further studies of the biology of the more important parasites with particular reference to alternate hosts and the inter-relations of some of the species among the large parasite complex found attacking *C. fumiferana* are being continued with considerable interest.

In carrying out the work involved in this study a great deal of credit is due to a number of individuals and organizations without whose help its success would not have been possible. We should like to express our gratitude particularly to Dr. C. D. Orchard, Deputy Minister of the British Columbia Department of Forests, and to his officers at Kamloops, Lytton and Lillooet, B.C.; also to the British Columbia Security Commission for their active help in connection with the field studies. We are also grateful for the taxonomic assistance given by Messrs. Walley, Peck and Brooks of the Systematic Unit at Ottawa.

PREVIOUS RECORDS OF PARASITES REARED FROM *C. FUMIFERANA*

Extensive insect parasitism of *C. fumiferana* has been noted by a number of observers in Canada and the United States. From an examination of the literature 44 species have been recorded. These records, however, give little precise information as to the importance of many of the species or of the interrelationships of the parasites. In the case of many of them the exactness of the records

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is somewhat questionable and in most cases their rôle as control factors is unknown. Of the 44 recorded parasites only 31 were referred to by species, the remainder were determined only to the genus. In only one of all the species recorded was reference made to their status as primary or secondary parasites of this host. A list of species previously recorded as parasites of *C. fumiferana* is given below with the authority and reference citation in brackets. In listing the Ichneumonidae the nomenclature and arrangement of the Townes' catalogue (1944) has been followed throughout.

HYMENOPTERA

Ichneumonidae.

Ichneumoninae:

Coccygomimus pedalis (Cress.), [Forbush and Fernald, 1896; Fiske, 1903; Cushman, 1920a; Wilkes and Anderson, 1947], *Ephialtes* of Cushman.

**Coccygomimus sanguineipes* (Cress.). [Bedard, 1938], *Ephialtes* of Bedard, (*vide* Townes, 1944).

Ephialtes ontario (Cress.), [Johannsen, 1913; Cushman, 1920a; Johnson, 1927; Brown, 1941; Coppel, 1947; Wilkes and Anderson, 1947], *Pimpla* of Johannsen, *Apechthis* of Brown, Cushman and Johnson, (*vide* Townes, 1944).

**Iseropus coelebs* (Walsh), [Johnson, 1927].

**Itoplectis atrocoxalis* (Cress.), [Bedard, 1938].

Itoplectis conquisitor (Say), [Johannsen, 1913; Cushman, 1920a; Twinn, 1938; Brown, 1941; Wilkes and Anderson, 1947], *Ephialtes* of Cushman and Twinn, *Pimpla* of Johannsen, (*vide* Townes, 1944).

Itoplectis obesus Cush., [Cushman, 1920a; Tothill, 1923; Mathers, 1932; Coppel, 1947], *Ephialtes* of Cushman and Mathers, (*vide* Townes, 1944), *Itoplectis* sp. of Tothill.

**Itoplectis quadricingulatus* (Prov.), [Bedard, 1938]. Referred to by Bedard as *I. esuchus* and synonymized with *I. quadricingulatus* by Townes (1944).

**Scambus atrocoxalis* (Ashm.), [Bedard, 1938], *Epiurus atrocoxalis* of Bedard, (*vide* Townes, 1944).

Scambus hispae (Harr.), [Viereck, 1912; Hewitt, 1913; Mathers, 1932; Coppel, 1947; Wilkes and Anderson, 1947], *Epiurus innominatus* Vier. of Hewitt and Mathers, (*vide* Townes 1944), *S. indagator* of Wilkes and Anderson.

**Scambus* probably *alboricta* (Cress.), [Wilkes and Anderson, 1947].

**Scambus* sp., [Wilkes and Anderson, 1947].

Theronia atalantae (Poda), [Cushman, 1920b], *T. fulvescens fulvescens* (Cress.) of Cushman (*vide* Townes, 1944).

Tryphoninae:

Phytodietus fumiferanae Rohw., [Rohwer, 1922; Tothill, 1923; Mathers, 1932; Wilkes, 1946; Coppel, 1947; Wilkes and Anderson, 1947], *Phytodietus* sp. of Tothill.

tes of Cushman.

Cryptinae:

Gelis tenellus (Say), [Wilkes and Anderson, 1947].

Phaeogeninae:

Phaeogenes hariolus (Cress.), [Viereck, 1912; Hewitt, 1913; Tothill, 1923; Bedard, 1938; Brown, 1941; Lambert, 1942; Coppel, 1947; Wilkes and Anderson, 1947], *Herpestomus* of Bedard, *Phygadeuon*

plesius Vier. of Hewitt and *Phygadeuon* sp. of Tothill, (*vide* Townes, 1944).

Lissonotinae:

Glypta fumiferanae (Vier.), [Viereck, 1912; Hewitt, 1913; Tothill, 1923; Bedard, 1938; Brown, 1941 and 1946b; Mills, 1942; Coppel, 1947; Wilkes and Anderson, 1947]; *Conoblasta* of Hewitt, *Glypta* sp. of Tothill, (*vide* Townes, 1944).

**Pimplopterus* sp., [Wilkes and Anderson, 1947].

Ophioninae:

**Horogenes* sp., [Coppel, 1947].

Mesochorinae:

**Mesochorus diversicolor* (Vier)., [Viereck, 1912; Hewitt, 1913].

Braconidae:

Apanteles fumiferanae (Vier)., [Hewitt, 1912 and 1913; Gibson, 1912; Viereck, 1912; Johannsen, 1913; Treherne, 1915; Muesebeck, 1920; Tothill, 1923; Brown, 1946a; Coppel, 1947; Wilkes and Anderson, 1947], *Apanteles* sp. of Johannsen and Tothill.

**Ascogaster* sp., [Brown, 1941].

Bracon probably *politiventris* (Cush.), [Wilkes and Anderson, 1947].

**Bracon* sp., [Coppel, 1947].

Meteorus trachynotus Vier., [Viereck, 1912; Tothill, 1923; Muesebeck, 1923; Brown, 1941; Wilkes and Anderson, 1947], *Meteorus* sp. of Tothill.

**Microgaster* sp., [Mills, 1942; Wilkes and Anderson, 1947].

**Rogas* sp., [Wilkes and Anderson, 1947].

Chalcididae.

Pteromalinae:

Amblymerus verditer (Nort.), [Gibson, 1910; Hewitt, 1911; Treherne, 1915; Tothill, 1923; Brown, 1941; Coppel, 1947], *Nasonia tortricis* Brues of Gibson, Hewitt and Treherne, *Nasonia* sp. of Tothill.

**Amblymerus* sp., [Brown, 1941].

**Hypopteromalus* sp., [Brown, 1941].

Encyrtinae:

**Copidosoma* sp., [Wilkes and Anderson, 1947].

**Encyrtinae*, [Wilkes and Anderson, 1947].

Eulophinae:

**Eulophus* sp., [Brown, 1941].

Trichogramminae:

Trichogramma minutum Rly., [Hewitt, 1912 and 1913; Tothill, 1923; Treherne, 1915; Bedard, 1938; Wilkes and Anderson, 1947], *Pentarthron* of Hewitt and Treherne, (*vide* Girault, 1911).

DIPTERA:

Sarcophagidae.

Pseudosarcophaga affinis (Fall.), [Wilkes, 1946; Coppel, 1947].

Sarcophaga sp., [Brown, 1941].

Tachinidae.

Aplomya caesar (Ald.), [Tothill, 1913; Brown, 1941; Wilkes and Anderson, 1947], *Exorista nigripalpis* Tns. of Tothill, *Zenillia caesar* of Brown, (*vide* Sellers, 1943).

Ceromasia auricaudata Tns., [Tothill, 1913; Wilkes, 1946; Coppel, 1947], *Masicera rutila* Meig. of Tothill (*vide* Brooks, 1945).

Gymnophthalma interrupta (Curr.), [Brown, 1941], *Actia*, of Brown, (*vide* Townsend, 1940).

Lypha setifacies (West.), [Brown, 1941; Brooks, 1945; Coppel, 1947; Wilkes and Anderson, 1947]; *L. dubia* Fall. of Brown, (*vide* Brooks, 1945).

Nemorilla pyste (Wlk.), [Tothill, 1913; Bedard, 1938; Brown, 1941], *N. floralis* (Fall.) of Bedard, *N. maculosa* Mg. of Brown and *Exorista pyste* of Tothill.

Omotoma fumiferanae (Tot.), [Hewitt, 1913; Tothill, 1912, 1913 and 1923; Brown, 1941; Coppel,, 1947; Wilkes and Anderson, 1947], *Winthemia* of Brown, Hewitt and Tothill, (*vide* Townsend, 1940).

Phorocera incrassata Smith, [Wilkes, 1946; Coppel, 1947].

Phryxe pecosensis (Tns.), [Tothill, 1913; Johannsen, 1913; Brown, 1941; Wilkes and Anderson, 1947], *Zenillia vulgaris* Fall. of Brown, *Exorista vulgaris* Fall. of Johannsen and Tothill, (*vide* Sellers, 1943).

*Species *not* reared from *C. fumiferanae* in the present study.

SITE OF THE PRESENT INVESTIGATIONS

In 1943, a preliminary survey was undertaken with the co-operation of members of the staff of the Forest Insects Laboratory, Vernon, B.C., in an attempt to locate suitable areas for the collection of spruce budworm parasites for transfer to Eastern Canada. Areas covered in the survey included Vancouver Island and a number of points in the central part of the mainland of British Columbia. Although spruce budworm was not found to be especially abundant in any of the areas examined, in almost all the collections made in the wooded section of the Fraser Valley, particularly near Lillooet, three species of parasites were found which had not been previously recorded in the east.

In view of the relatively greater abundance of the budworm at Lillooet and the immediately surrounding areas and the unusual accessibility of the terrain, the collecting work was confined largely to this general locality. In 1943, small collections of budworm were made on Mt. McLean, near Lillooet, and on Mission Mountain, near Shalalth.

In 1944 large-scale collections were made, mainly on Mt. McLean, Mission Mountain and on the mountain range near McGillivray Falls. During the summer of 1945, large-scale collections were made only on McLean and Mission Mountains, in 1946 on Mt. McLean and at Texas Creek and in 1947 at Mt. McLean, Texas Creek and Fountain Valley. The location of the collecting points is shown in figure 1. In all the areas, collecting could be carried out only along a somewhat narrow band on the wooded slopes of the mountains from approximately the 1000 to 3700 foot elevation. This band is referred to by Glendenning (1921) as comprising the Arid Transition Zone (1000 to 1700 ft.) and the Humid Transition Zone (1700 to 3700 ft.) of Merriam.

In addition to the sites selected for large-scale collecting, other areas in neighbouring budworm infestations were examined and collections made wherever posible for parasite rearing. The results obtained at two of these points are included in the present paper. One was located at Texas Creek on the mountain slope east of the Fraser river, seven miles north of Lillooet, and the other was in Fountain Valley about five miles northwest of Lillooet.

METHODS OF COLLECTING

The general methods and equipment used in the collecting and rearing of the budworm and its parasites have been essentially the same as described in a previous paper by Wilkes (1946). During the 1946 season some changes were made in the method used for removing the budworm larvae from the trees, and in the use of large cloth mats spread on the ground below the trees. An outline of the technique used that year has been given by Coppel (1946).

In addition to the large-scale collections made each day throughout the peak period of budworm development in the field for transfer of the parasites to Eastern Canada, special collections were made in order to obtain more precise information on the number of species and their abundance in the various localities. These collections were made at regular seven-day intervals, beginning at about the third stage of larval development and were continued until the moths began to emerge. The most complete records of this type were obtained at McLean and Mission Mountains. In these areas the special collections were made on the same day at each of three elevations, i.e. 1000, 2000 and 3000 feet. Each collection was then segregated into two groups representing those collected as larvae and those collected as pupae. Approximately ten per cent. of each collection was placed directly into preserving fluid and set aside for dissection. These were used to obtain immature stages of the parasites and to provide additional information on the abundance of the various species. The remainder were placed individually into vials and reared for parasite emergence at a temporary field laboratory set up for this purpose at Lillooet. All the adult emergents were pinned and recorded on special emergence cards. At the end of the season the remainder of the collections were transferred to Belleville where incubation was completed and the parasites were identified.

PARASITES REARED DURING THE PRESENT STUDY

During the course of the present work 45 species of parasites and one predator were reared from the collections of *C. fumiferana*. It will be noted in the list given below that 18 species recorded here have not been previously reported while 19 of the species previously recorded were not reared from budworm in the present study. Eleven of the latter species, *Iseropus coelebs*, reported from Maine by Johnson (1927), *Ascogaster* sp., *Hypopteromalus* sp., *Amblymerus* sp., and *Eulophus* sp. recorded by Brown (1941) from the Forest Insect Survey in Eastern Canada and *Scambus alboricta, Scambus* sp., *Pimplopterus* sp., *Rogas* sp., *Copidosoma* sp., and *Encyrtinae* sp., reported by Wilkes and Anderson, (1947), were recorded from budworm collected in the east and it is, therefore, possible that localities covered in this study do not come within the area of their present distribution. This may also be true of five other species, *Itoplectis atrocoxalis, Itoplectis quadricingulatis, Coccygomimus sanguineipes* and *Scambus atrocoxalis* reported by Bedard (1938) from Idaho and *Microgaster* sp. reported by Mills (1942) from Montana, although in these cases the distances involved are not nearly so great. It is quite likely that the *Itoplectis* sp. recorded from B.C. by Tothill (1923) is the same as *Itoplectis obesus* listed in the present work. On the other hand, *Mesochorus diversicolor* reported as being recovered from *C. fumiferanae* collected in Quebec and British Columbia by Hewitt (1913) was not reared from this host during the present study in British Columbia. The representatives of the two genera, *Horogenes* and *Bracon* from B.C. referred to by Coppel (1946) are in all probability the same as the two species *H. cacoeciae* and *Bracon* near *politiventris* listed in the present work.

The following is a list of the parasites reared from *C. fumiferana* during the present study. Where it is known, reference is made to the status of the parasites, i.e. whether primary (P) or hyperparasite (H), and the stage of the host attacked in the case of the primary species.

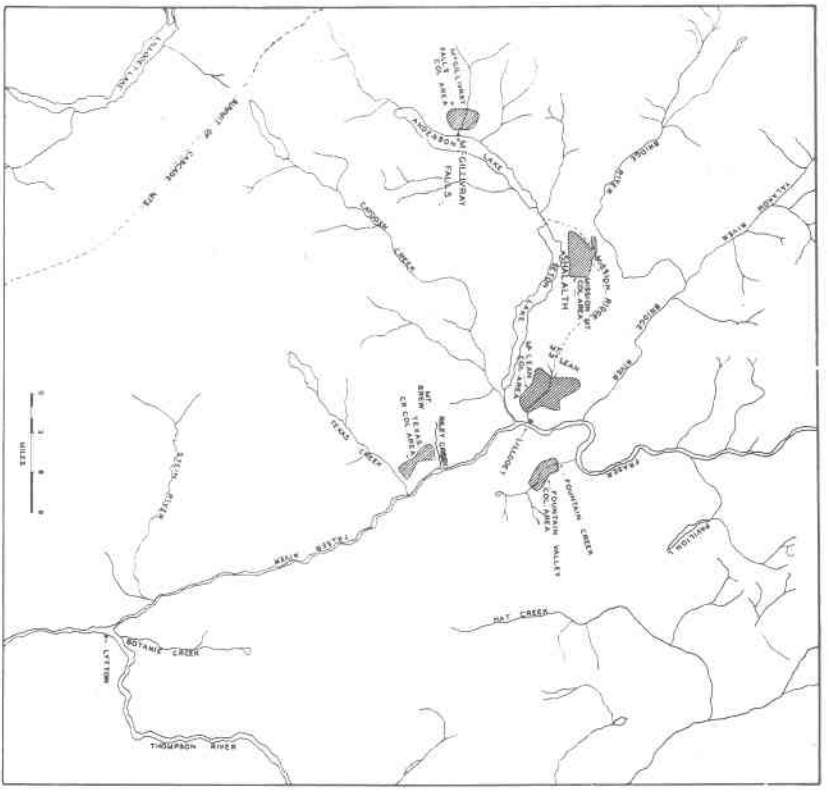

FIGURE 1. Location of the budworm collecting points in the Lillooet area of B.C.

HYMENOPTERA	Status	Stage attacked
Ichneumonidae.		
Ichneumoninae:		
Coccygomimus pedalis (Cress.)	P.	Pupae
Ephialtes ontario (Cress.)	P.	Pupae
Itoplectis conquisitor (Say)	P.	Pupae
Itoplectis obesus Cush. Occasionally hyperparasitic on *Phytodietus fumiferanae*	P.	Pupae
Scambus hispae (Harr.) Ex. *Glypta* and *Phytodietus*	P. and H.	Larvae
Theronia atalantae (Poda)	P.	
Tryphoninae:		
Phytodietus fumiferanae Rohw.	P.	Late Larvae
Cryptinae:		
Gelis tenellus (Say)	H.	
**Otacustes crassus crassus* (Prov.)		
Phaeogeninae:		
**Amblyteles* sp.		
Phaeogenes hariolus (Cress.)	P.	Early stage pupae.
**Pterocormus audax* (Cress.)		
**Pterocormus audax* (Cress.)		
Lissonotinae:		
Glypta fumiferanae (Vier.)	P.	1st and 2nd stage larvae
Mesoleiinae:		
**Euceros* probably *thoracicus* (Cress.) ex *Phytodietus* sp.	H.	
Metopiinae.		
**Exochus* sp.		
Ophioninae:		
**Campoplex* probably *validus* (Cress.)		
Horogenes cacoeciae (Vier.)	P.	1st and 2nd stage larvae
**Labrorychus* sp.		
Mesochorinae:		
Mesochorus sp. Ex *Glypta, Phytodietus* and *Apanteles.*	H.	
Braconidae.		
Apanteles fumiferanae Vier.	P.	1st and 2nd stage larvae
Bracon near *politiventris* (Cush.)	P.	Larvae
**Meteorus hyphantriae* Rly.	P.	
Meteorus trachynotus Vier.	P.	4th stage larvae
Chalcididae.		
Chalcidinae:		
Spilochalcis sp. Ex *Glypta* and *Apanteles*	H.	
Toryminae:		
**Monodontomerus montivagus* Ashm.		
**Monodontomerus* probably *subobsoletus* Gahan		

Pteromalinae:		
Amblymerus verditer (Nort.) Ex *Phytodietus*	H.	
**Habrocytus phycidis* Ashm.		
Eulophinae:		
**Tetrastichus* sp.		
Trichogrammatinae:		
Trichogramma minutum Rly.	P.	egg
DIPTERA		
Tachinidae.		
Aplomya caesar (Ald.)	P.	Larvae
Ceromasia auricaudata Tns.	P.	Larvae
Gymnophthalma interrupta (Curr.)	P.	Larvae
Lypha setifacies (West.)	P.	Larvae
**Madremyia saundersii* (Will.)	P.	Larvae
Nemorilla pyste (Wlk.)	P.	Larvae
Omotoma fumiferanae (Tot.)	P.	Larvae
**Phorocera erecta* Coq.	P.	Larvae and early stage pupae
Phorocera incrassata Smith	P.	Larvae
**Phorocera tortricis* Coq.	P.	
Phryxe pecosensis (Tns.)	P.	Larvae
Sarcophagidae.		
Pseudosarcophaga affinis (Fall.)	P.	Larvae and pupae
Sarcophaga sp.		
Phoridae.		
**Megaselia* sp.		
Muscidae.		
**Muscina stabulans* Fall. Probably a scavenger on late larvae and pupae.		
COLEOPTERA		
Cleridae.		
**Hydnocera lecontei* Wolc. Predator on late larvae.		

*Not previously recorded as parasites or predators of *C. fumiferana*.

RELATIVE ABUNDANCE OF THE PARASITES

On the basis of the work done up to the present it is somewhat hazardous to attempt to present statistics on the degree of parasitism by the different parasite species. In order to give reliable values in conventional terms of percentage parasitism observations must be made over a long period of time and from a large number of collections gathered at all stages during the development of the host in the field. This is particularly true in the case of *C. fumiferana*. In addition, rearing this species in the laboratory is a relatively difficult matter. Mortality is usually high, thus introducing another factor of uncertainty. More precise information on parasitism might be obtained by dissection of the hosts soon after the collections are made. At the present time, however, very little is known regarding the life-history of many of the parasites and therefore the various species cannot be identified with any degree of certainty by an examination of the immature stages. In view of these considerations the statistics on parasitism cannot be regarded as absolute values and indeed it must be kept in mind that in some cases they may be somewhat misleading.

In view of these qualifying reservations the abundance of the parasites as presented here can only be taken as an approximate guide to the numerical status of the parasites in the field, except in one area at Mt. McLean, where the study was carried out for a longer period and in considerably more detail than at other points. In most of the areas under study the work was conducted each season for a number of years and in some, the seasonal collections amounted to almost 500,000 individuals. Nevertheless, only a small proportion of the total number collected was taken over the entire period of budworm development. In view of these differences in methods of collecting the records of parasitism as shown in tables 1 and 2 are listed under two headings. In one, referred to as "special collections", the budworms were gathered at seven-day intervals beginning at the third stage of larval development and continued throughout the full period of development in the field. The other, referred to as "mass collections", was gathered largely during the late larval and pupal stages and, for the most part, when the population of these stages was at a maximum. The mass collections provided material for the large-scale transfer of certain species of parasites to Eastern Canada (*vide* Wilkes 1946). Thus, the special collections although they provide reliable data on the species attacking all stages of the budworm, are somewhat small in number, while the mass collections are numerically large but do not include some of the parasite species which emerge from the budworm during its earlier larval stages of development. Throughout the work considerable care was exercised in the identification of the host insects collected and therefore the parasites which emerged after rearing provide a definite record of the species parasitizing *C. fumiferana* in the areas under study.

An indication of the extent of parasitism and a list of the species involved in regulating the abundance of *C. fumiferana* in the Lillooet area of British Columbia may be obtained by an examination of the records shown in table 1 and 2. In both tables the degree of parasitism is calculated as a percentage of the total number of budworm placed in rearing. Whether or not an equal proportion of parasitized and unparasitized budworm died in rearing is unknown. It is assumed in the present study that mortality was the same in both. These provide an approximate measure of the percentages of the pest that are destroyed by each of the parasite species with the exception of the parasites attacking the eggs.

During 1946 and 1947 a number of collections of *C. fumiferana* egg-clusters was made and reared for the purpose of determining the importance of egg parasites. These consisted of three collections made on Mt. McLean in 1946 and 1947 and one in Fountain Valley in 1947. In each case the eggs were taken from trees selected at random throughout the infestations. From these the only parasite reared was the chalcid, *Trichogramma minutum* Rly. The degree of parasitism by this species is shown in table 3.

Table 3. *Trichogramma minutum* reared from *C. fumiferana* collected at Mt. McLean and Fountain Valley, B.C.

Locality	Year	Number of egg-clusters reared	Number of egg-clusters parasitized	Percentage of egg-clusters parasitized	Percentage of eggs parasitized
Mt. McLean	1946	2000	12	0.60	0.03
Mt. McLean	1947	395	43	10.89	0.99
Fountain Valley	1947	1617	13	0.80	0.42

It will be noted in the table that parasitism of *C. fumiferana* eggs in both the areas under study was quite low.

Table 1. Parasites reared from *C. fumiferana* collected at Mt. McLean, B.C. Parasitism is shown as the percentage number of each species reared from the total number of budworm placed into incubation each year.

	Special Collections					Relative abudance	Mass Collections			
	1943	1944	1945	1946	1947	1943-1947	1944	1945	1946	1947
Number of budworm reared	3332	912	6686	4217	2678		78700	103526	358890	166539
HYMENOPTERA										
Ichneumonidae										
Campoplex sp.			.03			.03				.002
Coccygomimus pedalis							.001		.0006	
Ephialtes ontario	.88	6.69	.51	.47	1.20	1.95	1.05	.47	.16	.77
Euceros probably *thoracicus*									.001	
Exochus sp.	.03					.03				
Gelis tenellus	.03					.03				
Glypta fumiferanae	1.45	7.23	7.34	2.06	7.84	5.18	12.85			
Horogenes cacoeciae							.001			
Itoplectis conquisitor							.02			
Itoplectis obesus	.34	.33	.72	.12	.11	.32	.16	.06	.04	.29
Labrorychus sp			.02			.03		.001	.0003	
Mesochorus sp.			.08			.08				
Otacustes crassus crassus	.03					.03				
Phaeogenes hariolus	.06	1.75	.81	.55	.37	.70	.09	.30	.02	.01
Phytodietus fumiferanae	10.65	3.18	1.58	2.80	.97	3.83	5.19	3.92		
Pterocormus audax								.003	.0008	
Scambus hispae	.03		.46			.09			.0006	.0006
Theronia atalantae							.001		.003	
Braconidae										
Apanteles fumiferanae		.41	1.49	.07	1.16	.79	.06			

	Special Collections					Relative abudance	Mass Collections			
	1943	1944	1945	1946	1947	1943-1947	1944	1945	1946	1947
Meteorus hyphantriae	.03					.03				
Microbracon near *politiventris*					.04	.04				
Chalcididae										
Amblymerus verditer			.57	.47	.42	.49	.01	.001	;007	
Habrocytus phycidis					.11	.11	.001			
Monodontomerus montivagus						.	.001			
Monodontomerus probably *subobsoletus*						.	.001			
Tetrastichus sp.				.14		.14				
Undetermined hymenopterous larvae				.29	.14	.21				
DIPTERA										
Tachinidae										
Aplomya caesar	.03	.11	.24	.07	.07	.10	.10	.08	.06	.06
Ceromasia auricaudata	.19	.66	1.58	3.75	4.14	2.06	8.65	4.62	1.73	4.68
Gymnophthalma interrupta								.001	.001	.003
Lypha setifacies			1.88	.85	1.23	1.32		3.58	2.63	3.56
Madremyia saundersii	.03	.22	.09	.71	2.20	.65	.44	.38	.58	2.67
Nemorilla pyste								.005	.001	.01
Omotoma fumiferanae		1.86	3.14	2.92	1.72	2.41	.89	6.48	3.43	3.38
Phorocera erecta	.47	.66	.13	.05		.33	1.78	.05	.03	.02
Phorocera incrassata	.94	1.54	.18	.07	1.68	1.10	.05	.04	.02	.50
Phorocera tortricis									.0003	.001
Phryxe pecosensis	.09	.88	.04	.33	.04	.27	.11	.06	.19	.24
Sarcophagidae										
Pseudosarcophaga affinis			.77	.12	3.99	1.63	3.07	.81	2.01	1.26
Sarcophaga sp.							.01			.0006
Undetermined sarcophagid larvae				2.42		2.42				
Muscidae										
Muscina stabulans								.03		.003
Undetermined Diptera				.07	.09	.08				
Total parasitism	15.28	25.55	21.67	18.33	27.52	26.48	33.53	20.89	10.91	17.46

Table 2. Parasites reared from *C. fumiferana* collected at Mission Mountain, Texas Creek, MacGillivray Falls and Fountain Valley. Parasitism was calculated in the same manner as in Table 1.

	Mission Mountain					Texas Creek			MacGillivray Falls	Fountain Valley
	Special collections			Mass collections		Special	Mass	Mass	Mass	Mass
	1943	1944	1945	1944	1945	1946	1946	1947	1944	1947
Number of budworm reared	1337	821	5189	114500	150689	481	25821	18557	29900	402170
HYMENOPTERA										
Ichneumonidae										
Amblyteles sp.				0.002	0.001					
Coccygomimus pedalis				0.003						0.0002
Ephialtes ontario	0.60	1.58	0.23	2.47	0.15	0.21	0.19	2.23	1.47	0.55
Exochus sp.										0.0004
Gelis tenellus				0.001					.02	
Glypta fumiferanae	5.40	7.92	6.82			1.25			3.86	
Horogenes cacoeciae			0.06							
Itoplectis conquisitor				0.01					0.01	
Itoplectis obesus	0.50		0.25	0.07	0.03	0.62	0.15	0.75	0.18	0.04
Labrorychus sp.			0.02							
Mesochorus sp			0.02							
Phaeogenes hariolus		0.12	0.10	0.04	0.03		0.01	0.22	0.15	0.09
Phytodietus fumiferanae	0.30	1.83	3.23	4.32	3.46	6.03	5.08		4.80	
Pterocormus audax					0.001					0.0002
Scambus hispae			0.10	0.001					0.007	0.06
Theronia atalantae				0.001						0.003
Braconidae										
Apanteles fumiferanae	0.10	0.36	1.73						0.50	0.61
Meteorus trachynotus			0.02							
Microbracon near *politiventris*							0.01			

	Mission Mountain					Texas Creek		McGillivray Falls	Fountain Valley
	Special collections			Mass collections		Special	Mass	Mass	Mass	Mass
	1943	1944	1945 MacGillivray	1944	1945	1946	1946	1947	1944	1947
Chalcididae										
Amblymerus verditer			0.08				0.01		0.02	0.07
Habrocytus phycidis				0.002						0.001
Spilochalcis sp.			0.02							
Undetermined hymenopterous larvae						0.21				
DIPTERA										
Tachinidae										
Aplomya caesar		0.24	0.17	0.60	0.06		0.02	0.05	0.03	0.003
Ceromasia auricaudata	9.30	9.50	0.65	13.06	2.30	8.73	4.94	10.42	6.61	1.09
Gymnophthalma interrupta								0.02		0.002
Lypha setifacies			2.44	0.02	10.14	0.21	0.28	0.03		0.04
Madremyia saundersii	0.07	0.24	0.02	0.50	0.13	0.42	0.54	1.15	0.03	0.09
Nemorilla pyste				0.01	0.01			0.02		0.002
Omotoma fumiferanae		5.12	6.16	5.50	13.55	2.29	3.39	1.70	14.86	1.63
Phorocera erecta	0.07		0.13	0.37	0.11	0.21		0.005	0.82	0.003
Phorocera incrassata	0.60	0.73	0.02	0.06	0.08		0.02	0.35	0.16	0.07
Phryxe pecosensis		0.24		0.36	0.05	0.42	0.60	0.06	0.19	0.02
Sarcophagidae										
Pseudosarcophaga affinis			0.08	1.58	0.24		1.02	1.37	3.43	6.15
Sarcophaga sp.				0.02						0.02
Undetermined sarcophagid larvae						3.12				
Phoridae										
Megaselia sp.					0.001					
Muscidae										
Muscina stabulans					0.001					0.08
Undetermined Diptera						0.21				
COLEOPTERA										
Cleridae										
Hydnocera lecontei			0.08							
Total Parasitism	7.93	27.88	22.43	29.00	30.344	23.93	16.26	18.375	37.147	10.624

Although complete records on the number of eggs in each cluster and the number of eggs parasitized could not be made, representative samples from each collection were examined in detail and from these it was found that less than 1 per cent of the eggs were parasitized by *T. minutum*. Even at Mt. McLean in 1947 where almost 11 per cent of the egg clusters were parasitized, on the average only 52.3 per cent of the eggs in the clusters were attacked. The number of eggs per egg-cluster varied from 10 to 80 with a mean of 35. The average number of parasites per egg-cluster was 47.5 and the sex-ratio was 80.4 per cent females. Thus it was calculated that an average of 2.1 parasites were produced per parasitized egg. This low degree of parasitism is somewhat surprising in view of Hewitt's (1912) record of 43 per cent egg parasitism at Esquimault, B.C. in 1911.

The extent of parasitism in the other stages of development (larvae and pupae) may be seen in tables 1 and 2. Of the 45 species of parasites listed, however, only 27 were found from the rearing records obtained in the present study to be primary on *C. fumiferana,* 7 were known to be hyperparasites and the rôle of 11 is as yet unknown. This is shown in tabulated form in table 4. The last group is relatively unimportant from the standpoint of control since only a few specimens were taken, often not more than one individual of a species, even from the very large collections.

Table 4. The rôle of the different species of parasites attacking *C. fumiferana.*

Stage of host attacked	Number of parasite species	Status as a parasite		
		Primary	Hyperparasite	Unknown
Eggs	1	1		
Overwintering larvae	3	3		
3rd stage to mature larvae	16	15	1	
Pupae	5	5		
Unknown	20	3	6	11
Totals	45	27	7	11

Of the parasites known to be primary, by far the greatest proportion (about 75 per cent) attack the larval stages of the host and to a large extent during the later stages of development. Only three species, *Glypta fumiferanae, Apanteles fumiferanae* and *Horogenes cacoeciae* parasitize early stage *C. fumiferana* larvae. These deposit their eggs in the host larvae soon after eclosion and remain within the host during diapause until the following spring. The adults usually emerge before completion of the host's fifth larval stadium and thus some of these species may not be reared from the collections if they are gathered late in the season. With the exception of *T. minutum,* the remainder of the more abundant primary parasites attack the late larval and pupal stages of the host. Only three (12 per cent) of the more abundant species, *Ephialtes ontario, Phaeogenes hariolus* and *Itoplectis obesus* parasitize the pupae. Although both *Phorocera erecta* and *Pseudosarcophaga affinis* have been observed on occasions to parasitize newly formed pupae, they appear to prefer fully mature larvae.

It is apparent from inspection of the tables that the overall controlling effect of the parasites on all stages of the host combined was relatively high. From the rearing records shown in tables 1 and 2 it may be seen that in some localities up to almost 40 per cent of the budworm collected were parasitized. In the older infestations at Mt. McLean, Mission Mountain and MacGillivray Falls the percentage parasitism was noticeably higher than at either Texas Creek or Fountain Valley where the infestations first appeared in noticeable numbers in 1946. At Mt. McLean (table 1) parasitism has remained at much the same level of 26 per cent during the past four years with the exception of 1946 when it dropped to 18

per cent. In tables 1 and 2 comparable values for total parasitism may be obtained by adding to the mass collection the percentage parasitisms of the three species not recorded in the mass collections, namely, *Glypta fumiferanae, Phytodietus fumiferanae* and *Apanteles fumiferanae*. From the special collections of the corresponding years at Fountain Valley, where mass collecting was possible for the first time in 1947, total parasitism based on the rearing of over 400,000 budworm but exclusive of *Glypta* and *Phytodietus* was just over 10 per cent. In this area *Pseudosarcophaga affinis* was by far the most abundant species present.

From the figures shown in the tables it is clear that not all the parasite species taken in the present study are of significant importance as factors of control. Of the 45 species recorded only 15 appear to be dominant in the parasite complex. These are listed in their relative order of importance as follows. In each case the species name is followed by an indication of their relative percentage parasitism (see table 1).

Glypta fumiferanae	5.18
Phytodietus fumiferanae	3.83
Omotoma fumiferanae	2.41
Ceromasia auricaudata	2.06
Lypha setifacies	1.32
Ephialtes ontario	1.95
Pseudosarcophaga affinis	1.63
Phorocera incrassata	1.10
Trichogramma minutum	0.99
Apanteles fumiferanae	0.79
Phaeogenes hariolus	0.70
Madremyia saundersii	0.65
Phorocera erecta	0.33
Itoplectis obesus	0.32
Phryxe pecosensis	0.27

Most of the others were either hyperparasitic or of infrequent or casual occurrence in the native parasite fauna of *C. fumiferana* in the Lillooet area.

SUMMARY

Extensive collections of the spruce budworm, *Choristoneura fumiferana* were made in the Lillooet area of British Columbia from 1943 to 1947 for the purpose of securing parasites for transfer to infested areas in Eastern Canada. In addition to the parasite species selected for liberation many others were reared which provided the basis for a study of the general parasite complex of *C. fumiferana* in this area.

In all, 45 species of primary and secondary parasites and one coleopteran predator were reared from the collections. Eighteen of these have not previously been reported in the literature as parasites of *C. fumiferana* and nineteen species previously recorded were not taken during the current studies. A list is given of the parasite species recorded in the literature from this host previous to the present work.

Of the 27 primary species, the majority attack the host larvae. *Trichogramma minutum* was the only egg parasite reared and it was never very abundant. Over-wintering larvae were parasitized only by *Glypta fumiferanae, Apanteles fumiferanae* and *Horogenes cacoeciae*. Fifteen species attack the larvae during their later stages of development and in most cases remain within the host until after it has pupated. Five species parasitize pupae. The stage of the host attacked by three species is unknown.

Only 15 of the total number of species taken appeared to be dominant in the parasite complex and are considered of significant importance as factors of control. Most of the others were either hyperparasitic or of infrequent or casual occurrence in the native parasite fauna of *C. fumiferana* in the Lillooet area.

The overall controlling effect of parasites in all stages of the host's development combined was high. In some years over 40 per cent of the budworm collected were parasitized. In the older infestations parasitism appeared to be definitely higher than in the more recent ones.

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"The Spider Book — A Manual for the Study of Spiders and their Near Relatives, the Scorpions, Pseudo-scorpions, Whip-scorpions, Harvestmen, and other Members of the Class Arachnida, Found in America North of Mexico, with Analytical Keys for their Classification and Popular Accounts of their Habits" by John Henry Comstock. Revised and edited by J. W. Gertsch. 729 pages, 770 figures. Comstock Publishing Company, Inc., Ithaca, New York. 1948. $6.00.

The Spider Book has been out of print for a number of years. Originally published in 1912, it has served as an excellent introduction to the study of the Arachnids, the spiders in particular. Primarilyl adapted for student use, it has proven a useful reference for teachers and arrachnologists.

The author of this revision, J. W. Gertsch, Ph.D., Associate Curator, Department of Entomology, American Museum of Natural History, is a well-known arachnologist, well qualified to undertake the revision. No radical departures in form or scope from the original edition have been introduced. Controversial topics have been avoided. The sections on classification have been revised to bring the text matter into line with present knowledge of genera and species. The manual does not make reference to every species and to every genus occurring in America north of Mexico, as this would be incompatible with the purpose of the manual.

This volume should meet the present day needs of student arachnologists, as well as serving as a handy reference for teachers and entomologists in general.